Comments by reviewer #2 – Connor Turvey

We thank Connor Turvey for the helpful and detailed comments. They will certainly improve the manuscript, particularly the section focussing on mineralogy. Please see our response to the individual comments including potential changes to the manuscript below.

General Comments

This paper covers three separate (but interlinked) concepts, it identifies the mineralogy of cryogenic cave minerals (CCM) found in Cove Cave in Greenland, demonstrates that dating information can be extracted from fine grained cryogenic cave carbonates (CCC_{fine}, which has proven difficult in other studies) and uses those dating results and other information to infer the circumstances that led to the formation of the CCM in Cove Cave.

Overall this paper seems coherent and well written, I would recommend this paper be accepted pending minor revisions. Detailed comments are provided below.

1. Does the paper address relevant scientific questions within the scope of CP? – Yes it looks at reconstructions of the past by looking at the CCC in a cave in Greenland and also shows how you can get age data from CCC_{fine}.
2. Does the paper present novel concepts, ideas, tools, or data? – Yes, age dating of CCC_{fine} is a novel tool.
3. Are substantial conclusions reached? – Yes, it identifies CCM in cove cave and determines their age and formation circumstances.
4. Are the scientific methods and assumptions valid and clearly outlined? - Yes
5. Are the results sufficient to support the interpretations and conclusions? - Yes
6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? – Needs improvement. The paper would be improved if they showed more of their mineralogy data (such as XRD diffractograms), and their methods could be more clearly written to allow fellow scientists to use the methods that they outline (eg they need to more explicitly how they are making their mixtures).

Please see what we plan to change in the specific comments below.

7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution? – Yes they seem to be citing other relevant work, but they could cite more studies related to the CCM presence/absence of other Greenland caves.

To the best of our knowledge, there are no other studies on CCMs in Greenland.

8. Does the title clearly reflect the contents of the paper? - Yes
9. Does the abstract provide a concise and complete summary? - yes

10. Is the overall presentation well structured and clear? -yes
11. Is the language fluent and precise? - yes
12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? - yes
13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? - No
14. Are the number and quality of references appropriate? - Yes
15. Is the amount and quality of supplementary material appropriate? – No, we could do with more of the mineralogy either in the text or in the supplementary information.

We will add the XRD diffractograms to the appendix.

Specific Comments

37 – It would be good to explicitly state the criteria for differentiating CCC_{fine} from CCC_{coarse}, presumably a grainsize limit.

This is a good point. We will add a statement on the differentiating criteria (mostly grain size and isotopic composition as a result of two different formation mechanisms).

70 – It would be better to report an approximate distance from Cove Cave to the weather stations rather than just saying ‘closest’.

We will add the approximate distances to the weather stations.

83 – A quick definition for what ‘inactive’ means in this context might be helpful, presumably it is common in speleothem geology but I am unfamiliar with it.

We will add a short explanation that could look something like this: “inactive flowstones (i.e., without active water supply)”.

91 – Should probably change “rather low” to something less casual.

Will do.

105 – Were there any obvious visual differences (color, texture etc) between the samples during collection?

No, there were not, all samples were taken from the same accumulation of CCMs and any visual differences were discovered later. We will put that into the text.

110 – Clarity could be improved here, are you taking sample KC19CCC-4, splitting it into different mineral fractions and then mixing the relative amounts? Or are you mixing KC19CCC-4 with another phase?

We split KC19CCC-4 into different mineral fractions and then mixed the relative amounts. We will change the phrasing to improve clarity.

116 – More analytical details for the mineralogy and crystal morphology analysis would be good. For example, with the XRD what was your scan range and analysis time?

We will add more detail here and add XRD diagrams to the appendix.

166 – Why could you not ID the very fine brownish crystals? Even if it was too fine to manually separate under a microscope for analysis you had XRD data and could identify the other crystals in the sample so I would have thought it should be possible by process of elimination.

Based on XRD results, the fine brownish crystals could contain quartz, potassium feldspar or dolomite. We will add that to the text.

171 – An XRD figure either here or in the appendices showing the results from the 4 samples would be very useful as it would allow for easy comparison between the mineralogy of the four samples, rather than just having it written out.

As mentioned above, we will add XRD diagrams to the appendix.

249 – SEM may provide useful insights here, were any textures observed that could only be explained by synchronous formation (crystals intergrown etc)

We assume that the reviewer is referring to line 254.

We carefully examined the SEM images, however, we found no conclusive evidence of coeval crystal growth. We will add that to the text.

250 – Any idea where does the quartz, dolomite and potassium feldspar in KC19CCC-1 come from? Country rock?

The most probable source for dolomite in the CCM sample is dolomite, a host rock in the area. We will add this to line 249. Quartz and potassium feldspar are, most likely, detrital material that came into the cave either via water or aeolian transport. We will add this to the manuscript.

280 – No theory as to why your difference between $\delta^{18}O$ values of your CCC_{fine} vs. common speleothems is different to that seen in other studies?

Unfortunately, we don't have enough data to draw definite conclusions. Our hypothesis is that the isotopic composition of the source water from which the CCMs and common speleothems precipitated differed. The CCMs were deposited recently but the common speleothems from the same cave (and area) are older and were deposited during an earlier period in the Quaternary with different climatic boundary conditions compared to today. We will not yet disclose the age of the common speleothem samples as those results are intended for another publication and not of relevance here. Previous studies, on the other

hand, often compared CCMs and common speleothems of roughly the same geologic age. We will include this in the manuscript.

314 – Would be good to have a reference supporting your claim that there are not CCMs overserved in other caves in the area.

To the best of our knowledge, there are no other references that we could cite to support this statement. However, our statement is based on findings from two expeditions that were conducted as part of our project. We will add a sentence regarding this.